CHAPTER 1 - INTRODUCTION

SECTION 1. GENERAL

1.1.1 PURPOSE. This manual is a guide for military personnel and civilian forces who are concerned with the maintenance and repair of waterfront structures and related facilities.

1.1.2 SCOPE. This manual, together with References 1-1, 1-2, and 1-3, describes the principal causes of deterioration and failure of waterfront structures and facilities and prescribes measures for the maintenance and repair of these installations to retain them in continuous readiness for use by the Fleet and in military marine operations. The scope of the maintenance and repair shall be governed by the present and proposed future use of the structures and facilities, their anticipated life, and the cost of repair as compared to complete rebuilding.

1.1.3 COOPERATION AND COORDINATION.

1.1.3.1 Intraservice Functions. Cooperation and coordination of waterfront maintenance activities among the installation departments concerned should be continuous. Programs of properly planned and executed maintenance operations prevent undesirable interruptions of production on military installations. Measures for the protection of supplies in storage must be coordinated with the storage service primarily responsible for the care and preservation of stored items. Supply officers, through normal channels, provide standard items of materials and equipment for waterfront maintenance.

1.1.3.2 Interservice and Interdepartmental Functions. Cooperation and coordination in conducting waterfront maintenance are encouraged at all levels of command. Appropriate liaison should be established and maintained between major commands and installations in a geographical area. Cross-service assistance shall be provided as necessary in the interests of economy and maximum utilization of manpower and equipment.

SECTION 2. JOINT SERVICE RESPONSIBILITY

1.2.1 ARMY. Staff, command, and technical responsibility for maintenance and repair of waterfront structures at Army installations will conform to assignments set forth in AR 420-10 [1-4].

Requests for assistance should be forwarded through channels to the Director of Facilities Engineering, DAEN-FEZ, Office, Chief of Engineers, Forrestal Building, Washington, D.C. 20314.

1.2.2 NAVY.

1.2.2.1 Naval Facilities Engineering Command. The Naval Facilities Engineering Command is responsible for the provision of services to the operating forces of the Navy in regard to shore facilities and related engineering material and equipment. This Command provides technical support, advice, and assistance regarding maintenance of grounds, buildings, and structures and related services. This authority is delegated to the Commanders and Commanding Officers of NAVFAC's Engineering Field Divisions (EFDs) who provide overall technical guidance in operations and maintenance matters to these shore installations.

1.2.2.2 Commanding Officer. The Commanding Officer at each Naval shore installation is responsible for providing an adequate maintenance program. These responsibilities are usually delegated to the Public Works Centers or Public Works Departments, as appropriate.

1.2.2.3 Public Works Center/Public Works Department. At each Naval and Marine Corps Installation, the Commanding Officer of a Public Works Center or the Public Works Officer is responsible to the activity Commanding Officer for the provision of:

(1) Inspections and surveys to determine and identify defective conditions (NAVFAC MO-322 [1-5] sets up guidelines for inspection. It includes guides, check-off forms, reports, and record systems to be used in the program.)

(2) Recommendations for maintenance standards and procedures that affect industrial production or military operations.

(3) Dynamic Equipment Inspection/ Service (preventive maintenance) programs

(4) Trained and qualified personnel to accomplish effective maintenance

(5) Periodic supervisory personnel training, education, and certification in maintenance programs that utilize work improvement maintenance techniques.

(6) Inspections and instructions to assure that labor, materials, and equipment are used properly and safely in accordance with pertinent regulations, and that operations are planned and supervised by qualified personnel.

(7) Coordination with civilian and other governmental agencies that have similar maintenance capabilities.

1.2.2.4 Engineering Field Divisions. Design and assistance for maintenance and repair are available at NAVFAC's Engineering Field Divisions. They also have special expertise and responsibilities for wood preservation. They can provide the latest available information on specifications and procedures for wood preservatives and treatments.

1.2.3 AIR FORCE.

1.2.3.1 Directives. Policy and standards for the maintenance, repair, and minor construction of waterfront structures are set forth in Air Force Manuals 85-1 and 86-1 [1-6, 1-7].

1.2.3.2 Major Command Level. Design and assistance for maintenance and repair are available at each Major Command. Each major command will:

(1) Insure that effective preventive and corrective maintenance measures are established and accomplished at all installations under its jurisdiction.

(2) Provide qualified technical supervision for personnel engaged in these operations.

(3) Provide for training of personnel engaged in maintenance.

(4) Make certain that base civil engineer personnel engaged in direct field supervision of maintenance operations, or those who function independently of direct supervision, are technically competent and thoroughly familiar with the performance of all phases of this activity, as outlined in this publication.

1.2.3.3 Air Force Installations. The Base Civil Engineer will:

(1) Plan, initiate, and supervise the execution of maintenance.

(2) Insure that in-house maintenance personnel are trained.

(3) Investigate the occurrence of and reasons for failures and accidents.

(4) Inspect and determine the effectiveness of safety measures.

SECTION 3. MAINTENANCE STANDARDS, POLICIES, AND CRITERIA

1.3.1 STANDARDS. The standards or criteria contained in this manual have been developed by the Army, Navy, and Air Force with the concurrence and approval of the Assistant Secretary of Defense (I&L). Compliance with these standards is mandatory in order that the maintenance of waterfront facilities at military installations will be uniform, will adequately support the operational missions of the installations, and will permit interservice assistance and support, where possible, in the interest of efficiency and economy.

1.3.2 ENGINEERING. The need and accomplishment of major repairs and rehabilitation of existing waterfront facilities will be based on experience, judgment, and/or engineering evaluation. When waterfront structures are in an inactive status, the maintenance policies will be consistent with the anticipated future mission of the installation and in accordance with the inactivation plan. The services of qualified technical personnel will be used to assist in the establishment of waterfront maintenance programs. A glossary of waterfront terms is provided in the back of this manual.

1.3.3 RELATED PUBLISHED MATERIAL.
Requirements for the design and construction of waterfront facilities are found in References 1-2, 1-3, and 1-8 through 1-13. References 1-14 and 1-15 are manuals prepared by the American Association of Port Authorities on port design and construction and on port maintenance, respectively. Reference 1-16 is especially important relative to inspection of waterfront structures. Reference to other published materials, which provide related or more extensive information on specific areas of waterfront maintenance, is made where appropriate throughout this manual and its Appendixes.

SECTION 4. TERMINOLOGY

1.4.1 PRIMARY CONSIDERATIONS. The upkeep of waterfront structures and other harbor facilities falls into the following areas of consideration: (1) Inspection, (2) Maintenance, (3) Repair and Reconstruction, and (4) Control of Marine Organisms.

1.4.1.1 Inspection. Inspection is the act of checking, visually and mechanically, the condition of facilities. This inspection should be performed on a routine basis, as indicated in this manual. The evaluation of the inspections will determine the degree of hazard involved with each structure. This degree of hazard will be used to determine the priority sequence of repair and the extent of repair required.

1.4.1.2 Maintenance. Maintenance is the recurrent day-to-day, periodic, or scheduled work that is required to preserve or restore a facility to such a condition that it can be effectively utilized for its designed purpose. It includes work undertaken to prevent damage to or deterioration of a facility that otherwise would be more costly to restore. Drainage is the single most important maintenance procedure. Water on, in, below, above, or anywhere near a structure creates special maintenance problems.

1.4.1.3 Repair and Reconstruction. Repair is the restoration of a facility to such a condition that it can be effectively utilized for its designed purpose. The repair is accomplished by overhaul, reprocessing, or replacement of constituent parts or materials that have deteriorated by action of the elements or usage and have not been corrected through maintenance. Repair can be incorporated in a concurrent modernization program.

1.4.1.4 Control of Marine Organisms. This control begins with the use of materials resistant to marine organisms when waterfront structures and other harbor facilities are designed and constructed. The control is a continuing requirement involving the taking of all known corrective measures and providing effective countermeasures to inhibit the growth of destructive organisms in waterfront facilities.

1.4.2 TYPES OF STRUCTURES. Waterfront facilities are structures and facilities that provide service for:

(1) Transferring ordnance, other cargo, and passengers
(2) Refueling ships
(3) Storing goods
(4) Supplying utilities to home-based vessels
(5) Berthing, constructing, overhauling, and repairing ships
(6) Conducting military marine operations
(7) Protecting the shoreline

1.4.2.1 Pier. A pier (Figure 1-1) is a deck structure supported above the water on piles (open type), a solid-fill structure retained by bulkheads (closed type with apron), or a combination of the two. It extends outward from the shore into a harbor or other navigable waters to permit berthing along one or both sides of its length.

1.4.2.2 Wharf. A wharf or quay (Figure 1-2) is a deck structure supported above the water on piles (open type),

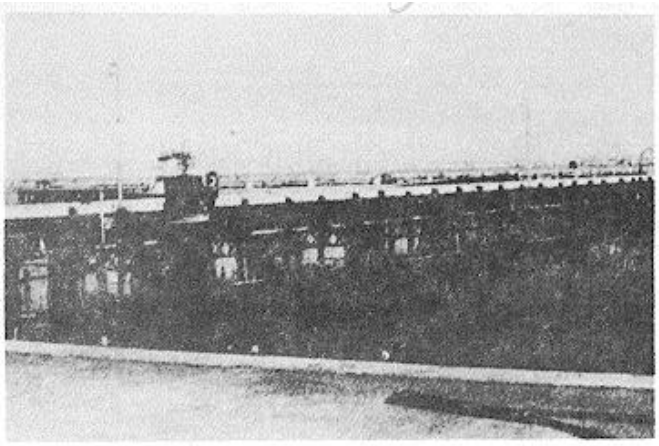

Figure 1-1. Open-type pier.

a solid-fill structure retained by bulkheads (closed), or a combination of the two. It runs parallel to the shore and is connected to it at more than one point (usually continuously) to provide berthing normally along one side.

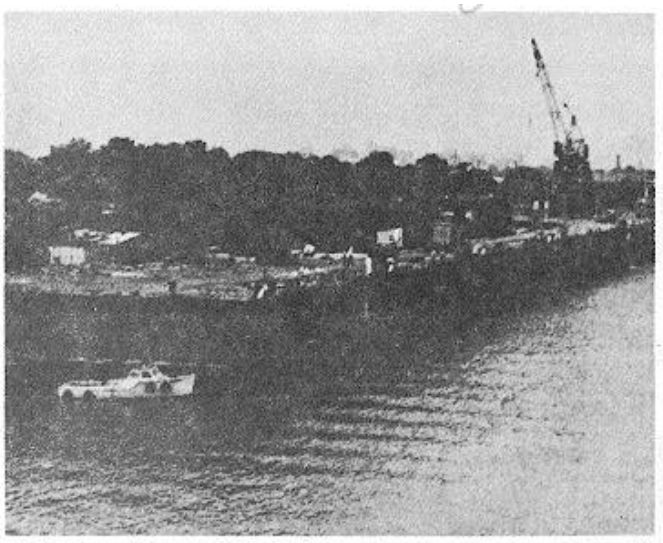

Figure 1-2. Example of a wharf.

1.4.2.3 Dolphin. A dolphin (Figure 1-3) is a structure usually consisting of one or a group of piles. It is placed near piers and wharves or in turning basins and ship channels (1) to guide vessels into their moorings, (2) to fend vessels away from structures, shoals, or the shore, (3) to support navigation aids, or (4) to moor a vessel.

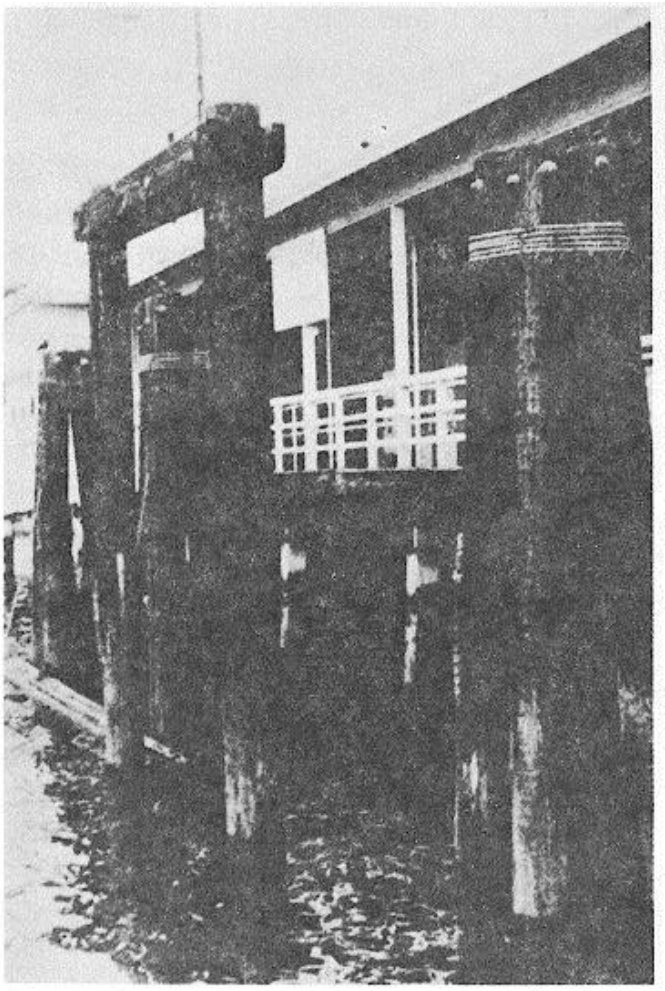

Figure 1-3. Example of a dolphin.

1.4.2.4 Fleet Mooring. A fleet mooring is an offshore ship anchoring system that consists of a ground tackle arrangement of chain or cable, sinkers, and anchors or other holding devices placed on the bottom of an anchorage. It is connected by means of a riser chain (or chains) to a buoy (riding on the surface of the water) whereby a ship can be made fast to the buoy. Maintenance of fleet moorings is described in Reference 1-17; it is mentioned in this manual only to identify fleet moorings as an important type of waterfront structure requiring regular maintenance.

1.4.2.5 Drydocking System. A drydocking system is a facility for exposing the normally underwater portion of a ship for construction, inspection, modification, repair, or

hull maintenance. Several different types are listed below.

1.4.2.5.1 Graving Dock. A graving dock (Figure 1-4) is a fixed basin usually of stone masonry, concrete, or piling cells adjacent to the water's edge. It can be closed off from the waterway by a movable watertight barrier (entrance caisson or flap gate). It can, therefore, be pumped dry, allowing a ship to settle down on blocking set on the dock floor.

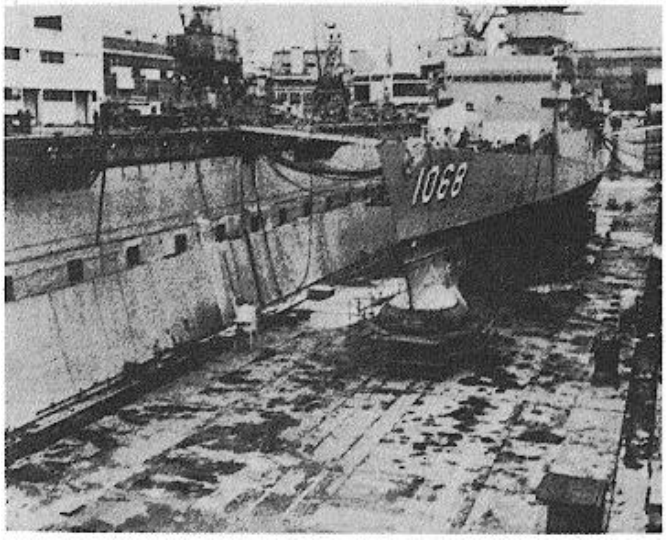

Figure 1-4. Graving dock with ship installed.

1.4.2.5.2 Floating Drydock. A floating drydock is a ship or U-shaped structure that can be submerged by flooding to permit a vessel to enter and then later be pumped dry to raise the vessel out of the water. Maintenance and operation of floating drydocks will not be discussed in this manual.

1.4.2.5.3 Marine Railway. A marine railway (Figure 1-5) consists of an inclined groundway extending into the water, a mobile ship cradle on wheels or rollers, groundway ship cradle tracks, hoisting machinery, and chains or cables for hauling the ship cradle endwise or sidewise.

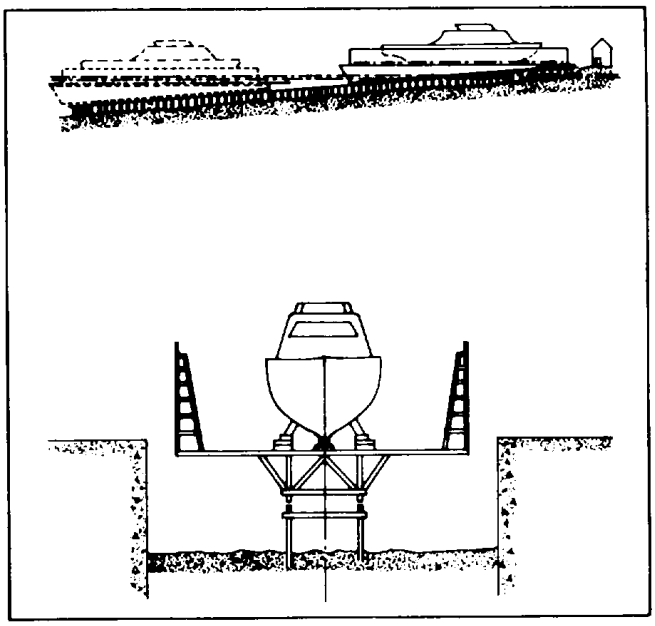

Figure 1-5. Example of a marine railway.

1.4.2.5.4 Vertical Lift. A vertical lift drydock (Figure 1-6) is a platform which is lowered into the water to receive a ship, and then elevated out of the water by electrically, pneumatically, or hydraulically powered hoisting equipment.

1.4.2.6 Quay Wall. A quay wall (Figure 1-7) is a barrier of steel, stone, concrete, or wood that supports an embankment or fill built as a part of a waterfront structure.

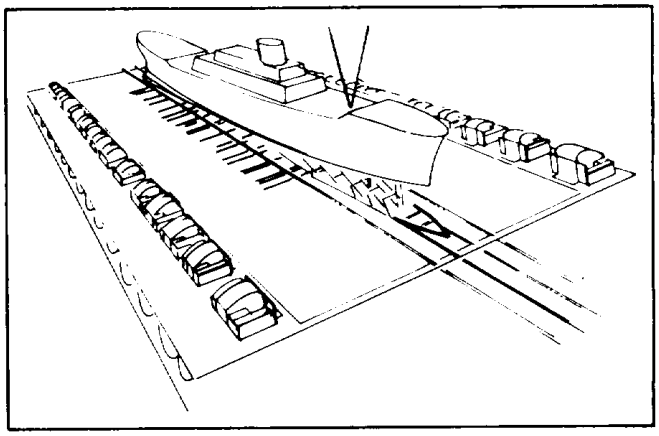

Figure 1-6. Example of a vertical lift drydock.

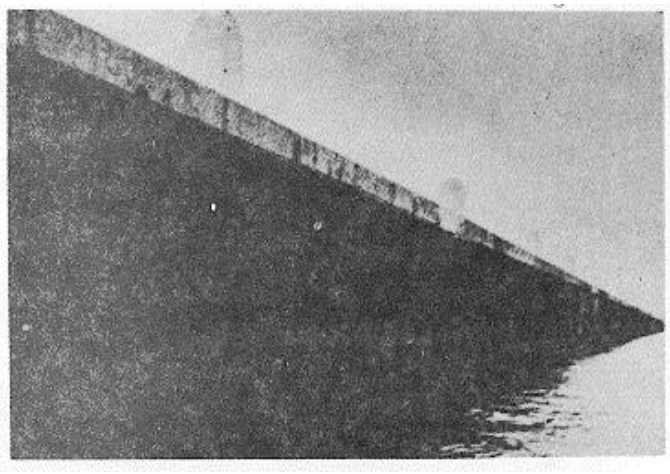

Figure 1-7. A quaywall.

1.4.2.7 Mole. Moles are normally earthen structures that extend outward from shore into the navigable waters of the harbor (Figure 1-8). The sides and offshore end of a mole are retained or protected by riprap, sheet-pile bulkhead of either prestressed or reinforced concrete, or a gravity-type wall of either masonry or concrete. Such a structure is sometimes used as a breakwater. Generally, the level top is appreciable in area and may contain paved roads, railroads, and crane trackage. If the sides and offshore end of a mole are protected by either a bulkhead or a gravity-type wall, the structure can be used to berth vessels, provided the depth of water is adequate.

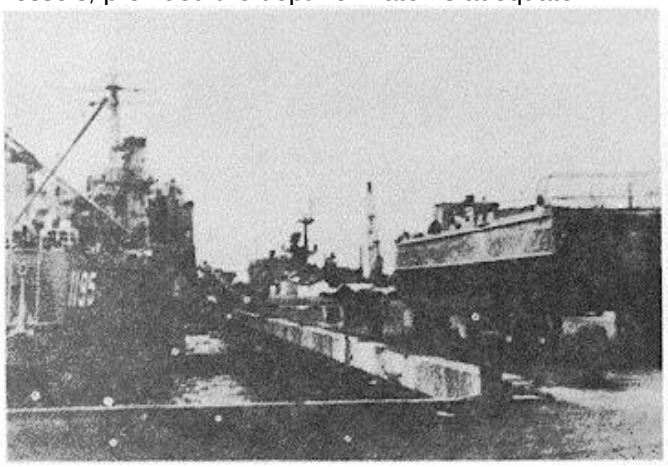

Figure 1-8. Example of a mole.

1.4.2.8 Jetty. These structures, which are located at the entrance to a harbor or in a river estuary, extend from the shore into deeper water to prevent the formation of sandbars and to direct and confine the flow of water due to currents and tides (Figure 1-9). Jetties are usually constructed of mounds of large rubble to an elevation several feet above high tide. They are generally lower in height than breakwaters and are designed to offer less resistance to waves than breakwaters and seawalls. Jetties should be dense enough to prevent sand from entering the entrance channel.

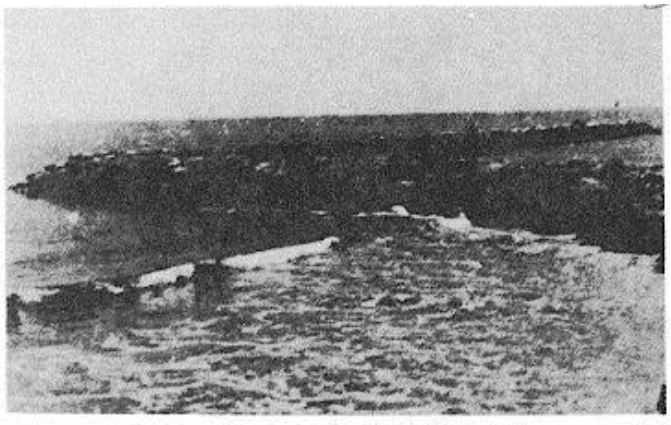

Figure 1-9. Example of a jetty.

1.4.2.9 Breakwater. These are substantial structures, located at the outer limits of a harbor or anchorage, to protect the inner waters against the effects of heavy seas and winds and to ensure safe mooring, operating, loading, or unloading of shipping within the harbor (Figure 1-10). These durable barriers usually consist of rubble-mound structures and are often covered with heavy, large rocks or reinforced concrete armor units. There are three general types of breakwaters, depending on type of exposed face: (1) vertical, (2) partly vertical and partly inclined, or (3) inclined. Breakwaters may be either detached from the shore or shore-connected.

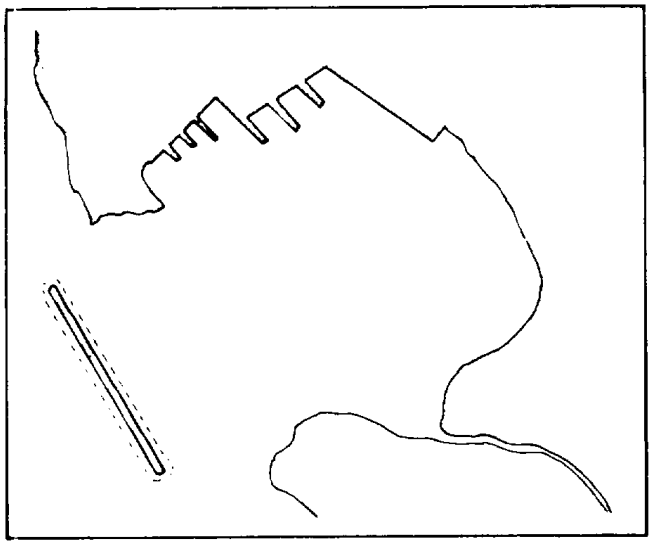

Figure 1-10. Example of the placement of a breakwater.

1.4.2.10. Groin. These structures control the rate of shifting sand by influencing offshore currents and wave action in a manner such that erosion of the shoreline is prevented or minimized (Figure 1-11). Generally, the longtime effect of groins is an increase in the width of the beach. These narrow structures may be perpendicular to the shoreline and are constructed of large rocks (at least 1 ton each), precast concrete units, reinforced or prestressed concrete piles, steel sheet piles, or timber cribbing filled with rock. The most common type of groin is the high, dense one that is designed to catch the drifting sand until the sand is forced around the offshore end.

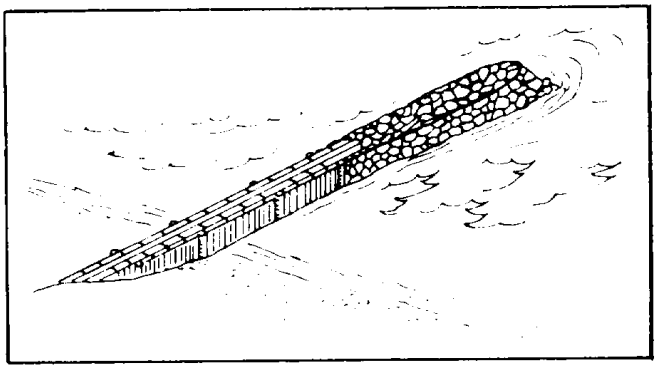

Figure 1-11. A groin.

1.4.2.11 Seawall. These are massive structures, built along and parallel to the shoreline, that are designed to protect coastal areas against erosion caused by wave action and flooding during heavy seas (Figure 1-12). The seawalls are constructed of rubble-mound, granite masonry, or reinforced concrete. They are usually supplemented with steel or concrete sheet pile driven into the beach and strengthened by wales and brace-type piles.

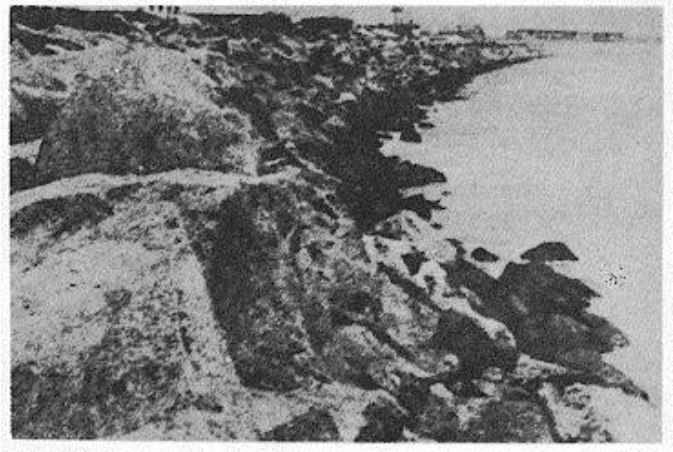

Figure 1-12. Example of a seawall.

1.5.1 PROGRAMMING. The maintenance program for waterfront structures and other harbor facilities shall be developed to include the prevention and prompt detection of deficiencies or damage and the quick performance of maintenance or repairs in an economical and workable manner. Replacement or repair of damaged parts should be made as soon as possible because when one item is not working, the remaining parts are more easily damaged. These requirements are essential to the maintenance standards established by higher authority.

1.5.2 ECONOMIC REQUIREMENT. In the maintenance of waterfront facilities thorough consideration shall be given to the overall economy of the facility. Of particular importance is a complete study of the replacement cost of the facility in relation to the expected life span and the cost of repairs. Other factors to be considered include the following: prompt detection of deficiencies or damage and the expeditious performance of maintenance or repairs in an economical and workable manner. Replacement or repair of damaged components should be made as soon as possible because of:

(1) Possible obsolescence of the facility
(2) The present adequacy of the facility
(3) The present and future availability of maintenance funds
(4) The operational economics of downtime involved in major repair or replacement of facilities.

1.5.3 CAUSES OF DETERIORATION. The deterioration of waterfront facilities is caused PLANNING by exposure to destructive forces, such as:

(1) Attack by fungi, termites, and marine organisms
(2) Corrosion
(3) Mechanical damage, including the impact and pressure of ships and cargo and the abrasive action of sand, ice, and debris
(4) Erosion due to wind and wave action, tides, water currents, rain, snow, sleet and ice, and freezing and thawing.

1.5.4 INSPECTION. Waterfront facilities shall be inspected periodically to determine the extent of the maintenance and repair work required. References 1-1 and 1-16 set up the Navy's guidelines for inspection and include essential information on guides, check-off forms, reports, and record systems to be used in the program. It is recommended that inspections be made annually of all basic structures and more frequently for fenders and movable equipment, such as brows and camels. Additional inspections may be necessary under certain circumstances, such as tidal waves, high tides, earthquakes, typhoons, heavy freezes, etc. Inspections may be made from the structures, from a boat or float, or from below the water line by divers. (See Appendix A for details on diver inspections.) Underwater television is often employed in visual inspections.

SECTION 6. PREPARATION FOR WORK

1.6.1 FIELD MEASUREMENTS. During inspections, wear, corrosion, alignment, deflection, etc. may be estimated. Where there is any question as to the degree of hazard, an accurate engineering investigation shall be made. Facilities to be repaired shall be carefully measured so that construction details can be designed and estimates of required materials prepared. Material storage areas should be designated and laid out at this time so that interference with traffic is minimized. Field measurements should include the exact location of underground utilities so that they can be avoided or relocated as necessary.

1.6.2 AS-BUILT DRAWINGS. "As-built" drawings, if available, should be used in programming the repairs rather than the original drawings, because these drawings should show all deviations from the original design and changes made during the original construction. These drawings should be carefully compared with actual field observations to detect any changes that might have been made after completion of the as-built drawings.

1.6.3 SKETCHES. As a part of programming the repairs, sketches should be made to outline clearly the extent, sequence, and details of the repair operation. On other than major projects, freehand sketches, properly dimensioned and supplemented by notes, will be sufficient to permit an experienced maintenance man to carry out the work properly. All sketches should be clear and legible and should normally be reproducible. Copies of the sketches, properly identified as to location and date, should be filed with the job record and with the as-built drawings.

1.6.4 CHECKING STRUCTURAL STABILITY. Any evidence of damage or deterioration affecting the structural stability of any facility should be the subject of an immediate engineering study. This study should include the degree of hazard and recommendations as to what corrective measures are required.

SECTION 7. ACCESS TO WORK

1.7.1 DIVERS. No one skill is more essential to the proper performance of maintenance and repair work on waterfront structures than that of the diver. The diver, in addition to being certified, should be experienced in construction and familiar with construction tools and materials. The diver must also be able to report clearly and in exact detail underwater conditions (see Appendix A).

1.7.2 RAFTS AND/OR BARGES. Rafts or barges for general repair work should have a flat, open-deck area completely covered with planking that is reasonably tight to prevent both accidents to workmen and the loss of tools and equipment. The rafts can be supported on logs or pontoons. The structures should be rigid enough to withstand considerable shock. The raft should be equipped with well-secured cleats or other means for

securing lines. Rafts should be fitted with handrails or lifelines on the sides that are not adjacent to the work. Deck planking should be kept in repair by plugging any holes and replacing broken or cracked planks. Rafts with steel pontoons and framework should be kept painted to prevent deterioration and should have adequate fendering systems.

1.7.3 SCAFFOLDS. All scaffolding shall conform to all military and ASSHO safety regulations.

1.7.3.1 Wood Scaffolds. Wood scaffolds should be built to suit the particular work that is to be done from them. They should be rigid and completely stable in themselves, even when not secured to a structure. No less than two 10-inch-wide planks of 2-inch nominal thickness should be used as the platform. The unsupported span shall not exceed 10 feet. All planks used for scaffold platforms should be tested immediately prior to the installation of the framework. If no other means of testing is available, each plank should be placed flat and supported at each end by a block 12 inches high. The plank should then be loaded at its midpoint with twice the anticipated load on the scaffold, and the load left on for at least 5 minutes. If visible or audible failure occurs, or if the plank remains deformed after the load is removed, it should be discarded. All scaffold planks should be free of large knots, shakes, splits, checks, or any other visible defects. All scaffold planks should be securely fastened. Any scaffold plank that, by use or accident, becomes broken, cracked, warped, or in any way defective should be replaced immediately by a sound plank.

The strength of the scaffold framework should be more than sufficient for the height of the scaffold. No posts less than 4 inches by 4 inches should be used for a scaffold, and they should be securely cross-braced. Convenient access from the ground and from one level to another should be provided by ladders or stairs that are rigidly secured. All platform levels should have well-supported life rails. On the land side, supports must be placed on firm ground, preferably in such a manner that they can be wedged up or raised if necessary. If vehicles will pass adjacent to or near the scaffolding, substantial barricades should be placed at least 3 feet from the supports of the scaffold.

Fire extinguishers of adequate size shall be stationed near wood scaffolds to conform with fire regulations.

1.7.3.2 Pipe Scaffolds. Pipe scaffolds should be free of any bent, dented, or otherwise defective members. Every connector of each tier must be made tight before the next tier is installed. Joints and connectors in pipe scaffolds must be tightly bolted. Scaffold supports should be maintained in a vertical position.

1.7.3.3 Hung Scaffolds. Platform planking and life rails for hung scaffolds should be similar to those for built-up scaffolds. The rope or line used should be of more than ample size and free of defects; it should be secured to cleats, bitts, a string piece, or another substantial part of the structure. The scaffolds should also be equipped with a positive mechanical or structural means of belaying the free end of the rope or line.

1.7.4 LADDERS. All ladders should be made with sound, secure rungs notched into, or passing through,

the stringers. Broken or cracked rungs should be replaced immediately. Ladders should not be painted because this could conceal defects.

Wooden ladders shall be treated occasionally with clear linseed oil to prevent the wood from drying out. New ladders, especially those with hardwood rungs, should be dipped in a 5% pentachlorophenol solution for 3 minutes to deter rotting. If dipping is not possible, the solution should be brushed or sprayed on. Linseed oil need not be applied when the latter treatment has been used.

1.7.5 EXCAVATIONS. Excavations for repair work are normally required for access to underground parts of a structure. The safety of the structure during excavation is of prime consideration. The excavation should be made so that the surrounding ground does not lose its own stability or such support as it may be giving to the adjacent structure. This is accomplished by:

(1) Removing material in a manner so that a stable, sloping bank is created around the sides of the excavation.

(2) Driving vertical wood, concrete, or steel sheeting around the sides of the area to be excavated, and redriving the sheeting further as excavation progresses

(3) Installing breast boards around the sides of the excavation as it progresses downward.

(4) Driving soldier beams and placing breast boards between them as the excavation progresses.

Where excavations are necessary beneath the water table, it may be necessary to dewater the site to permit working in the dry. In such instances the major criteria to meet are those dealing with loss of stability of the bottom or sides of the excavation and removal of the water (see References 1-18 through 1-20).

In some cases it may be necessary to stabilize the soil prior to excavation by using, for example, electroosmosis for fine-grained soils, or freezing or grouting to stabilize the coarser soils (see Reference 1-18).

Necessary measures should be taken and careful observations made to be sure mud, silt, water slurry, and other excavation materials do not undermine adjacent roads, piers, fills, tracks, and facilities.

SECTION 8. SAFETY

1.8.1 INSTRUCTIONS. Safety precautions and safe maintenance practices are covered in detail in the following:

(1) Army EM 385-1-1 [1-21]
(2) Navy NAVFAC 5100.1 1 A [1-22]
(3) Air Force AFM 127-101 [1-23]

1.8.2 PERSONAL PROTECTION. Workmen in hazardous locations should wear life belts or safety belts (or both) attached to safety 1 lines according to the conditions at the site of the work and ASSHO regulations. Safety lines should be rigged with as little slack as possible. If the slack is more than two or three feet, a workman could be injured by even this short fall. Always use a safety belt, never a loop of rope around a man's body. Insist on workmen using hard hats, unless they are clearly unnecessary, and require them to wear safety glasses when chipping, grinding, or sandblasting. Safety shoes and other types of protective clothing are

frequently necessary and should be used. A respirator should be available for use should the need arise.

1.8.3 BARRICADES AND SAFETY LINES. All unsafe traffic areas, such as openings, interruptions, or breaks in deckings, roadways, or walkways, should be completely surrounded by adequate barricades. The barricades should be set sufficiently far back from the edge of the opening so that no person or vehicle can fall into the opening. The barricades should display plain, legible signs and lights to warn of the danger. If work of a particularly hazardous nature is being done on a deck, on the ground surface, or on an overhead structure or bulkhead, the affected area should be barricaded until it is again safe for traffic to proceed. Welding at or near the vehicular or pedestrian traffic area should be completely surrounded by a solid shield high enough to prevent direct view of the flame or arc.

1.8.4 TRAFFIC CONTROL. Traffic (both land and water) in and out and around of a waterfront area is of prime importance. Maintenance or repair operations should be organized in such a manner as to minimize traffic (including cranes) inconvenience. If it is necessary that a repair operation restrict traffic, the operations should be planned and the required barricades so constructed that, in case of an emergency, operations can be stopped and barricades removed in a reasonably short time. If repairs undertaken as a whole will restrict traffic, the repairs should be done in parts, if possible, so as to offer the least hindrance to traffic and base operation.

1.8.5 PROTECTION FROM MECHANICAL DAMAGE. All waterfront structures should be protected from mechanical damage, such as impact from ships and floating debris, insofar as practicable. Fenders are normally provided in berthing areas to cushion the impact of ships when docking. In some cases, it may be economical to provide dolphins for additional protection to waterfront structures. All special problems of protection of waterfront structures should be referred to design personnel of the activity or the appropriate Engineering Office.

1.8.6 BERTHING. Anchoring or mooring of ships or workbarges must vary with the nature of the work and take into account the rise and fall of the tide, currents, wind, waves, and traffic. The lines must be so placed that they will not be fouled by traffic using regular channels. Proper signals and lights must be displayed on craft anchored in a channel or turning basin. The berthing system should have sufficient reserve to allow for a sudden change to bad weather. All lines should be secured in such a manner that they are easily accessible and can be quickly let out or hauled in. Rafts tied alongside a structure should have fenders to prevent damage to the structure or raft. If weather predictions are such that damage to the raft or structure could happen, additional anchors or lines should be put out or the raft moved to a sheltered area.

1.8.7 CURRENTS. All supervisors of the repair force should be thoroughly familiar with currents in the river, harbor, or seafront on which a repair site is located. The velocity and direction of currents can change with varying conditions of tide, wind, and rainfall. Changes in the direction of the wind can alter currents by raising or lowering the water level along the sea front. Anchored or berthed vessels, if in a comparatively small or narrow

waterway, can also alter the current. A chart showing direction and velocity of currents in the area should be available at every repair site.

1.8.8 CHANGES IN TIDES. Tidal changes at waterfronts are usually regular and predictable unless they are affected by wind, which can alter the range of the tide considerably. The greatest variations take place in the tidal waters of a river where the river outflow to the sea is through a widening estuary. A chart should be available at the repair site that shows the range of tides and notes conditions anticipated with various wind velocities.